Method and apparatus for cold joining flanges and coupling elements to pipes

The invention relates to a system and a method for joining flanges or other coupling elements to pipes and a tool for performing the method.

Flanges of many types and varieties are used extensively in industry when pipe-to-pipe or pipe-to-other component connections are to be provided. The welding of flanges to pipes is the most common method in the case of steel pipes and standard weldable metals, whilst, for example, screw flanges are used in connection with, for instance, galvanised pipes.

In recent years a number of methods have been developed for the fastening of coupling elements and the joining of pipes by deforming the pipe inside the coupling so as to secure it. Other methods and equipment which clamp the coupling to the outside of the pipe without any or with little deformation of the pipe have also been developed. Examples of such methods are taught in US 4,593,448 and US 4,147,385. DE 27 24 257 and US 2,252,274 teach tools with rollers which by means of a rotating cone in the centre with rollers therearound will deform the pipe so that it fits into grooves in the coupling elements. DE 3144385 teaches a joining system for pipes where radially movable ridges, with the aid of hydraulic pressure against underlying pistons, press in beads. However, as discussed further below, the pipe wall on the side of the beads will buckle inwards, and when the ridges of the tool are retracted, the actual bead in the pipe will also retract somewhat, which makes the connection weak. In addition, there will be a metal-to-metal seal between pipe and coupling element, and therefore the system taught in the said document will require sealing material in the grooves of the coupling element. It has been found that with radial pistons as taught in DE 3144385 it is not possible to obtain an especially large radial force, and this principle could perhaps be used with particularly thin-walled pipes.

To deform a pipe wall into grooves in a surrounding coupling element requires very large forces if the pipe wall is to be pressed radially outwards. The use of rollers as described in DE 27 24 257 and US 2,252,274 means that less radial force is required, but on the other hand the tool must be secured to the pipe and therefore becomes large and heavy. Rolling subjects the material to harsher treatment and also takes longer than radial pressing.

The object of the invention is to provide a system for joining flanges or other coupling elements to pipes where the tool is only operated radially so that a fixing of the pipe is not necessary. Furthermore, it is an object to obtain a tool which even in connection with small pipe dimensions has enough force to deform beads in relatively thick pipe walls. It is also an object that the tool should function so that inward tapering of the pipe end, which has been found to be a problem in connection with the radial pressing of beads, is avoided.

Fig. 1 shows pipe and coupling elements before the beads (5, 6) are pressed in. Fig. 2 shows the same after the beads have been pressed into the coupling element. Fig. 3 shows a collar pressed into place for a loose flange. Fig. 10 shows a flange having spherical movability.

The principle of the tool is shown in Fig. 5, whilst different embodiments of the cone used as a mechanical force amplifier are shown in Figs. 6-8. Fig. 9 shows a tool with a hydraulic force amplifier.

During the development of the invention, which comprises both the interior configuration of the external coupling element and the tool which forms the beads, it was quickly discovered that the most critical parameter for optimal attachment resides in the configuration of the part of the tool that presses the beads and also the part of the tool that is to prevent the end of the pipe from tapering inwards during the pressing operation.

Figs. 1 and 2 show that the outermost portion (a) of the coupling element against which the pipe end (b) rests is flared outwards. This is to allow the tool to give the pipe end (b) an overbending outwards, which is necessary because the pipe end, as mentioned, tends to taper inwards. Thus, the pipe is almost straight after the beads (5, 6) have been pressed, as can be seen in the enlarged section in Fig. 2.

The same basic interior configuration of the coupling elements will apply to a collar for loose flanges as shown in Fig. 3, spherically movable flanges as shown in Fig. 4 and other types which may be suitable for the same fastening method.

It should be mentioned that the cylindrical part (c) of the coupling element as shown in Fig. 3 may advantageously be quite thin-walled. To a certain extent, the wall will then be resilient and yield a little during the pressing operation, and this will then mean that

afterwards it is under inward tension and thus provides further pressure in the connection where the pipe is in tension outwards.

Tests carried out in the laboratory show that a mechanically good seal is obtained between the grooves (3, 4) and the beads (5, 6). Nevertheless, it may be appropriate to insert a sealing material in one or more of the grooves.

According to Fig. 5, the principle of the tool is based on a plurality of segments (10) having circular ridges (11) being pressed out towards the pipe wall and forming the beads first. Towards the end of the pressing operation, the cylindrical part (13) of the segments is pressed against the pipe in the portions on the sides of the beads to prevent them from buckling inwards. This process is shown in Fig. 4a and Fig. 4b as well as in Fig. 11. Fig. 4a shows the pipe (1) and the coupling (2) before the pressing operation, and Fig. 11 is an enlarged view of the intermediate stage during the pressing where the aforementioned buckled-in areas (b) of the pipe on the side of the beads can be seen. In Fig. 4b it is seen that the cylindrical portions of the segments have pressed the buckled-in areas back towards the coupling element so that they lie almost flush with the diameter of the pipe. This after-pressing gives a powerful radial tensioning effect in the pipe which increases the contact pressure between pipe and coupling element in the sealing points between beads and grooves, and prevents the retraction of the pipe as mentioned above when referring to plain ridges as previously described in, for example, DE 3144385. Innermost on the segments there is provided a projection (14) which presses against the end of the pipe. In a corresponding portion of the coupling element there is a recess (a) which may be made in the form of a bevel edge or a cut-out. This cut-out can, for some uses, be partially filled with sealing material, or it may have an O-ring fitted therein. This special design of the tool and the coupling element has been found to be necessary in order to prevent the pipe from tapering inwards as previously mentioned.

The segments (10) and especially the ridges (11) are subjected to extremely large stresses during the pressing operation and are therefore made of hardened steel. Consequently large radial forces are also required to operate the segments. As an example thereof, the pressing of a connection of a steel pipe with an outer diameter of 76 mm and a wall thickness of 3.2 mm as shown in Figs. 2 and 3, with eight segments would require a radial force per segment of about 200 kN, in total a required force of about 1600 kN. These are huge forces within a very narrow space, and the tool

according to the invention therefore uses a power actuator outside the pipe combined with a force amplifier inside the pipe.

Fig. 6 shows the tool with a circular cone (20) as force amplifier, Fig. 7 shows the tool with the cone drawn in and the segments in expanded position. Fig. 8 shows the same tool with a polygonal pyramid as force amplifier.

Fig. 9 shows a tool with hydraulically operated segments where a segment (22) is shown separately and it can be seen that the segment is fastened to a piston (27) which can move in a corresponding cylinder in the housing (21) which is filled with oil. In the illustrated tool, there will thus be a total of eight pistons and eight cylinders. When the rod (25) is pressed into the housing, the oil will press the pistons (27) outwards. The greater the diameter of the piston in relation to the diameter of the rod, the greater the force amplification.

A cold joining of the coupling element of this kind means, unlike, for example, welding, that the material of the coupling is not given a modified surface structure. Therefore, the invention is suitable for couplings as shown in Fig. 10 where a spherical coupling element (30) is fastened to the pipe and where a two-part flange (31, 32) is screwed together, the two parts facing one another on each side of the coupling element. The flange will then be capable of being mounted at a variable angle relative to the pipe. It will either be freely movable, even after screwing, or will be such that it is locked to the coupling element (30) when the flange is tightened to another flange.